

Remarks

Support for the above-requested amendments to claim 1 is found at least at paragraph [0001] of the specification. The preambles of claims 2-8 and 10-15 have been amended to recite a "foam board" to correspond to the preamble of claim 1. Claims 12 and 13 have been amended to remove references to montmorillonite. Claim 21 has been amended to recite "acicular calcium carbonate". Support for the amendment to claim 21 is found at least in paragraph [0011]. Claims 23, 25, and 26 have been canceled without prejudice. Claims 9, 16-20, 22, and 24 were canceled in previous Amendments. No question of new matter arises and entry of the amendments is respectfully requested.

Claims 1-8, 10-15, and 21 are before the Office for consideration.

Objection to Claims 12 and 13

Claims 12 and 13 have been objected to under 37 C.F.R. §1.75(c) for failing to further limit the subject matter of a previous claim. In particular, the Office asserts that claims 12 and 13 recite "Montmorillonite", which is a nanoclay. The Office asserts that nanoclays have been removed from independent claim 1.

In response to this objection, Applicants have amended claims 12 and 13 to remove references to montmorillonite. In view of the above, Applicants respectfully request that this objection be reconsidered and withdrawn.

Rejection of Claims 21 and 23 under 35 U.S.C. §112, first paragraph

Claims 21 and 23 have been rejected under 35 U.S.C. §112, first paragraph, for failing to comply with the written description requirement. It is asserted that the original disclosure does not provide support for acicular nanoclays or graphites with at least one dimension less than 100 angstroms.

In response to this rejection, Applicants have amended claim 21 to remove acicular nanoclays and acicular graphites from the claim. Claim 23 is dependent upon claim 21, which, as amended, does not recite acicular nanoclays or acicular graphites. Therefore, Applicants respectfully request reconsideration and withdrawal of this rejection.

Rejection of Claims 1-8, 10-15, 25, and 26 under 35 U.S.C. §103(a)

Claims 1-8, 10-15, 25, and 26 have been rejected under 35 U.S.C. §103(a) as being unpatentable over WO 2001/39954 to Grinshpun, *et al.* ("Grinshpun") in view of U.S. Patent No. 6,589,646 to Morgenstern ("Morgenstern") or U.S. Patent Publication No. 2005/0027040 to Nelson, *et al.* ("Nelson"). The Office asserts that Grinshpun teaches a method of manufacturing a rigid foam that includes (1) incorporating fillers and at least one nucleating agent and reinforcing materials such as graphite, conductive carbon black, and nanofillers into a polymet, (2) incorporating a blowing agent into the melt under a first temperature and a first pressure, (3) extruding the polymer melt under a second temperature and second pressure to allow the polymer melt to expand and foam, and (4) cooling the foamed product. It is asserted that the foam has a cell size that ranges from 25-7000 microns. The Office admits that Grinshpun does not teach that the nano-particle fillers are calcium carbonate, intercalated graphite, or expanded graphite having the claimed particle size. However, the Office asserts that Morgenstern discloses that calcium carbonate having a particle size as low as 50 angstroms may be employed as an inorganic filler/nucleating agent in foam applications. Additionally, it is asserted that Nelson teaches the use of inorganic additives such as montmorillonite and calcium carbonate having a particle size as low as 20 angstroms in foam nanocomposites. The Office concludes that it would have been obvious to one of skill in the art to use the additives taught by Morgenstern or Nelson in the method of Grinshpun to provide an adequately reinforced foam material.

Initially, Applicants submit that claims 25 and 26 have been canceled without prejudice, thereby rendering the rejection of these claims moot.

In response to the rejection of the remaining claims, Applicants respectfully direct the Office's attention to independent claim 1 and submit that claim 1 defines a method of manufacturing a rigid foam board that is not taught or suggested within Grinshpun, either alone or in combination with Morgenstern or Nelson. Additionally, Applicants respectfully submit that none of Grinshpun, Morgenstern, or Nelson teach or suggest the combination of features recited in amended claim 1.

Initially, Applicants submit that Grinshpun teaches a method of making hollow foam tubes, not a method of manufacturing a foam board as claimed in claim 1. In Grinshpun, a foamable composition is extruded through a die that has a plurality of orifices, each of which forms a hollow extrudate. (*See, e.g.*, page 2, lines 19-21 and page 20, lines 22-24). The

hollow extrudate is converted into foamed hollow extrudate strands at a temperature that promotes bubble stability. (*See, e.g.*, page 2, lines 22-24 and page 20, lines 26-28). The final step includes permitting the hollow strands to contact and adhere to each other to form a hollow, multistrand polymer foam extrudate. (*See, e.g.*, page 2, lines 25-28 and page 20, lines 28-31). The extrusion die in Grinshpun is specifically chosen so that it forms the hollow tubes. On the other hand, in the presently claimed invention, a solid foam board is formed that has a specific cell size and cell distribution due to the use of nano-particles that have a particle size in one dimension less than 100 angstroms. Neither Morgenstern nor Nelson teaches an extrusion process as claimed. It is respectfully submitted, therefore, that the combination of Grinshpun with either Morgenstern or Nelson would not result in the presently claimed invention.

Also, it is respectfully submitted that Morgenstern teaches away from the use of a nano-particle having a particle size in one dimension less than 100 angstroms as claimed in claim 1. Applicants note that Morgenstern teaches nucleating agents that have particle sizes “generally from 0.005 to 10 μm ”. (*See, e.g.*, column 2, lines 58-67). However, Morgenstern specifically teaches that the particle sizes are “preferably from 0.01 to 1 μm ”. (*See, e.g.*, column 2, lines 58-67). In view of this teaching, Applicants respectfully submit that Morgenstern actually teaches away from the use of a particle having a size less than 100 angstroms (*i.e.* less than 0.01 μm) as is required by claim 1.

Further, Applicants submit that in order to evaluate the obviousness or non-obviousness of an invention, both the prior art reference(s) and the claimed invention as a whole must be considered. (*See, e.g.*, MPEP §2141.02 citing *Stratoflex, Inc. v. Aeroquip Corp.*, 713 F.2d 1530, 218 USPQ 871 (Fed Cir. 1983) and *Schenck v. Nortron Corp.*, 713 F.2d 782, 218 USPQ 698 (Fed. Cir. 1983)). As discussed above, Morgenstern teaches that the particles have a size from 0.005 to 10 μm and preferably from 0.01 to 1 μm . Applicants submit that these ranges, with minimal exception, are greatly outside the nano-particle range, *i.e.*, a range from 10-100 nm (*i.e.*, 0.01 μm to 0.1 μm).¹ Looking at Morgenstern as a whole, it is submitted that the particles utilized in Morgenstern are indeed not nano-particles, and, as a result, one of skill in the art reading Morgenstern would have no motivation to utilize a nano-particle with a particle size in at least one dimension less than 100 angstroms in a

¹ *See, e.g.*, Attachment A, <http://en.wikipedia.org/wiki/Nanoparticle>.

polymer melt to form a foam board with an average cell size greater than 60 μm as claimed in claim 1.

Turning to Nelson, Applicants respectfully submit that Nelson teaches a nanocomposite composed of at least one surface modified inorganic additive and at least one organic polymer. (*See, e.g.*, paragraphs [0015] and [0035]). In the outstanding Office Action dated December 26, 2007, the Office asserts that Nelson discloses additives that have a particle size as low as 2 nm (20 angstroms). (*See* page 4, lines 14-16). It is respectfully submitted that these additives pointed out by the Office are used to form the disclosed nanocomposite. Indeed, Nelson specifically teaches the use of these additives to form the organic/inorganic nanocomposite. There is no teaching or suggestion within Nelson that these additives are used as nano-particles in a foam melt. In fact, Nelson is silent with respect to any teaching or suggestion of the use of the additive as a nucleating agent or even as an additive to a foam, as claimed in claim 1. Accordingly, it is respectfully submitted that the combination of Grinshpun and Nelson, with or without Morgenstern, would not result in the method of claim 1.

In addition, Applicants submit that one of skill in the art reading the disclosures of Grinshpun, Morgenstern, and Nelson would have no motivation to incorporate nano-particles selected from calcium carbonate, intercalated graphites, and expanded graphites that have a particle size in at least one dimension less than 100 angstroms because (1) Grinshpun is silent as to any teaching or suggestion of a nano-particle with a particle size in one dimension less than 100 angstroms, (2) Morgenstern teaches away from the use of particles with a particle size less than 100 angstroms, and (3) Nelson is silent with respect to any teaching or suggestion of the use of the additive as a nucleating agent or even as an additive to a foam. To establish a *prima facie* case of obviousness, there must be some motivation, either within the reference or in the knowledge of those of skill in the art, to modify the reference or combine the references' teachings, there must be a reasonable expectation of success, and the prior art references must meet all of the claim limitations. (*See, e.g., Manual of Patent Examining Procedure*, Patent Publishing, LLC, Eighth Ed., Rev. 3, August 2005, §2142). There is simply no motivation within Grinshpun, Morgenstern, or Nelson to arrive at the method claimed in claim 1 that incorporates nano-particles with particle size in at least one dimension less than 100 angstroms in a polymer melt. Without some teaching or suggestion,

there can be no motivation, and without motivation, there can be no *prima facie* case of obviousness.

With respect to claims 2-8 and 10-15, Applicants submit that because independent claim 1 is not taught or suggested by Grinshpun, Morgenstern, and Nelson and claims 2-8 and 10-15 are dependent upon independent claim 1 and contain the same elements as claim 1, dependent claims 2-8 and 10-15 are also not taught by Grinshpun, Morgenstern, and Nelson.

In light of the above, Applicants submit that claims 1-8 and 10-15 are not obvious over Grinshpun in view of Morgenstern or Nelson and respectfully request that this rejection be reconsidered and withdrawn.

Rejection of Claims 1-8, 10-15, and 25-26 under 35 U.S.C. §103(a)

The Office has rejected claims 1-8, 10-15, and 25-26 as being unpatentable over WO 2001/40362 to Miller, *et al.* ("Miller") in view of U.S. Patent No. 6,589,646 to Morgenstern ("Morgenstern") or U.S. Patent Publication No. 2005/0027040 to Nelson, *et al.* ("Nelson"). In particular, the Office asserts that Miller teaches the claimed process of producing an extruded foam product where a blowing agent is incorporated into the polymer melt at a first pressure and temperature, extruding the polymer melt under a second pressure and temperature to form a foam, and intrinsically cooling the foam to form a product with a cell size within the claimed range. It is asserted that the preferred polymer melt includes an alkenyl aromatic polymer material. The Office admits that Miller does not disclose the incorporation of nano-particles in the polymer melt.

In this regard, Morgenstern is cited for assertedly teaching the use of calcium carbonate with a particle size as low as 0.005 microns as an inorganic filler/nucleating agent in foam applications. Additionally, the Office asserts that Nelson teaches the use of inorganic additives such as calcium carbonate with a particle size as low as 2 nm (20 angstroms). The Office concludes that it would have been obvious to one of ordinary skill in the art to employ the calcium carbonate of either Morgenstern or Nelson in the method of Miller to provide a reinforced foam material.

Initially, Applicants submit that claims 25 and 26 have been canceled without prejudice, thereby rendering the rejection of these claims moot.

In response to the rejection the remaining claims, Applicants respectfully direct the Office's attention to independent claim 1 and submit that none of Miller, Morgenstern, or

Nelson teach or suggest the incorporation of nano-particles selected from calcium carbonate, intercalated graphites, and expanded graphites that have a particle size in at least one dimension less than 100 angstroms in a polymer melt as required by claim 1. Morgenstern teaches nucleating agents that have particle sizes ranging from 0.005 to 10 μm . (*See, e.g.*, column 2, lines 58-67). Additionally, Morgenstern teaches that the particle sizes are “preferably from 0.01 to 1 μm ”. (*See, e.g.*, column 2, lines 58-67). Applicants submit that these ranges, with minimal exception, are vastly outside the nano-particle range, *i.e.*, a range from 10-100 nm (0.01 μm to 0.1 μm).² As discussed previously, in determining obviousness or non-obviousness, the prior art references and the claimed invention as a whole must be considered.³ Looking at Morgenstern as a whole, it is submitted that the particles utilized in Morgenstern are not nano-particles, and, as a result, one of skill in the art would have no motivation to incorporate a nano-particle with a particle size less than 100 angstroms in a polymer melt to form a foam board with an average cell size greater than 60 μm as claimed in claim 1. Indeed, Applicants respectfully submit that Morgenstern teaches away from the use of a nano-particle having a size less than 100 angstroms (*i.e. less than 0.01 μm*) as is required in claim 1. Accordingly, it is respectfully submitted that the combination of Grinshpun and Morgenstern fails to constitute the substantial evidence necessary to render the claimed invention obvious as a matter of law.

With respect to Nelson, Applicants submit that Nelson discloses additives that have a particle size as low as 2 nm (20 angstroms). (*See, e.g.*, paragraph [0041]). In order to improve compatibility, the additive's surface is modified. (*See, e.g.*, paragraph [0046]). These additives are used to form the disclosed nanocomposite. (*See, e.g.*, paragraph [0040]). Applicants submit that there is no teaching or suggestion within Nelson that these additives are used as nano-particles in a foam melt. Nelson specifically teaches the use of these additives to form the organic/inorganic nanocomposite by the disclosed method. Indeed, Nelson is silent with respect to any teaching or suggestion of the use of the additive as a nucleating agent or even as an additive to a foam. Accordingly, it is respectfully submitted that the combination of Grinshpun and Nelson, with or without Morgenstern, would not result in the invention claimed in claim 1.

² *See, e.g.*, Attachment A, <http://en.wikipedia.org/wiki/Nanoparticle>.

³ *See, e.g.*, MPEP §2141.02 citing *Stratoflex, Inc. v. Aeroquip Corp.*, 713 F.2d 1530, 218 USPQ 871 (Fed. Cir. 1983) and *Schenck v. Nortron Corp.*, 713 F.2d 782, 218 USPQ 698 (Fed. Cir. 1983).

In addition, Applicants submit that there is simply no motivation within any of Miller, Grinshpun, or Nelson to arrive at the polymer melt claimed in claim 1 that includes nano-particles selected from calcium carbonate, intercalated graphites, and expanded graphites having a particle size in at least one dimension less than 100 angstroms. Indeed, Morgenstern teaches away from a particle size of less than 100 angstroms. Miller and Nelson are silent with respect to any teaching or suggestion of the use of nano-particles having a particle size of 100 angstroms in one dimension in a polymer foam. As discussed above, there must be some motivation to modify the reference or combine the references' teachings. (*See, e.g., Manual of Patent Examining Procedure*, Patent Publishing, LLC, Eighth Ed., Rev. 3, August 2005, §2142). Without some teaching or suggestion, there can be no motivation, and without motivation, there can be no *prima facie* case of obviousness. Accordingly, Applicants submit that claim 1, and all claims dependent therefrom, are non-obvious and patentable.

With respect to claims 2-8 and 10-15, Applicants submit that because independent claim 1 is not taught or suggested by Miller, Morgenstern, and Nelson and claims 2-8 and 10-15 are dependent upon independent claim 1 and contain the same elements as claim 1, dependent claims 2-8 and 10-15 are also not taught by Miller, Morgenstern, and Nelson.

In light of the above, Applicants submit that claims 1-8 and 10-15 are not obvious over Miller in view of Morgenstern or Nelson and respectfully request that this rejection be reconsidered and withdrawn.

Rejection of Claims 1-8, 10-15, 21, 23, 25, and 26 under 35 U.S.C. §103(a)

The Office has rejected claims 1-8, 10-15, 21, 23, 25, and 26 as being unpatentable over WO 2001/40362 to Miller, *et al.* ("Miller") in view of WO 2003/055804 to Chen, *et al.* ("Chen") and U.S. Patent No. 7,160,929 to Tan ("Tan"). In particular, the Office asserts that Miller teaches the claimed process of producing an extruded foam product where a blowing agent is incorporated into a polymer melt at a first pressure and temperature, extruding the polymer melt under a second pressure and temperature to form a foam, and intrinsically cooling the foam to form a product with a cell size within the claimed range. It is asserted that the preferred polymer melt includes an alkenyl aromatic polymer material. The Office admits that Miller does not teach acicular nano-particles as claimed.

In this regard, Chen is cited for assertedly disclosing calcium carbonate whiskers/needles that have a particle size as low as 10 nm (100 angstroms). Additionally, the

Office cites Tan for teaching the use of nanofibers and nanopowders such as calcium carbonate in the production of nanocomposite foams. The Office concludes that it would have been obvious to one of skill in the art to employ the calcium carbonates of either Chen or Tan in the method of Miller for the purpose of producing a lightweight material having superior mechanical properties.

Initially, Applicants submit that claims 23, 25, and 26 have been canceled without prejudice, thereby rendering the rejection of these claims moot.

In response to the rejection of claims 1-8 and 10-15, Applicants respectfully direct the Office's attention to claim 1 and submit that claim 1 defines a method of manufacturing a rigid foam board that is not taught or suggested within Miller, Chen, or Tan. Specifically, Applicants respectfully submit that Miller, Chen and Tan do not teach or suggest the incorporation of nano-particles selected from calcium carbonate, intercalated graphites, and expanded graphites that have a particle size in at least one dimension less than 100 angstroms in a polymer melt as required by claim 1. Chen teaches that the disclosed method can produce small mean particle size, superfine calcium carbonate with a size in the range from 10 nm (*i.e.*, 100 angstroms) to 2.5 microns. (*See, e.g.*, paragraph [0048]). Chen does not, however, teach or suggest calcium carbonate having a particle size in at least one dimension less than 100 angstroms as required by claim 1. Indeed, Chen teaches away from a nano-particle having a particle size less than 100 angstroms. Moreover, Chen is silent with respect to any teaching or suggestion of calcium carbonate that is not manufactured to have a specifically formed shape, such as spindle, petal, whisker, needle, flake, ball, and fiber. (*See, e.g.*, paragraph [0001] and the Abstract). Chen is also silent with respect to any teaching or suggestion of intercalated graphites and expanded graphites.

Turning to Tan, Applicants respectfully submit that Tan teaches the use of calcium carbonate powder as a filling agent to produce a reinforced foam with improved mechanical properties. (*See, e.g.*, column 4, line 63 to column 5, line 17). Tan is, however, silent with respect to any teaching of the size of the calcium carbonate powder. The only nano-scale particles disclosed in Tan are reinforcing elements, namely, nano-scale ceramic powder, metal, and carbon fibers. (*See, e.g.*, column 3, lines 64-65 and column 8, lines 29-34). There is simply no teaching or suggestion within Tan of calcium carbonate, intercalate graphites, or expanded graphites having a particle size in at least one dimension less than 100 angstroms as required by claim 1.

In addition, Applicants submit that there is simply no motivation within any of Miller, Chen, or Tan to arrive at the polymer melt claimed in claim 1 that includes a nano-particle selected from calcium carbonate, intercalated graphites, and expanded graphites with a particle size in at least one dimension less than 100 angstroms. Both Miller and Tan are silent with respect to any teaching or suggestion of calcium carbonate having a particle size less than 100 angstroms in one dimension. Chen teaches away from a particle size of less than 100 angstroms. Additionally, none of the cited references teach or suggest the incorporation of intercalated or expanded graphites. There must be some motivation to modify the reference or combine the references' teachings. (See, e.g., *Manual of Patent Examining Procedure*, Patent Publishing, LLC, Eighth Ed., Rev. 3, August 2005, §2142). Without some teaching or suggestion, there can be no motivation, and without motivation, there can be no *prima facie* case of obviousness. Accordingly, Applicants submit that claim 1 is non-obvious and patentable.

Turning to the rejection of claim 21, Applicants submit that none of Miller, Chen, or Tan teach or suggest the inclusion of acicular calcium carbonate and at least one nucleating agent into a polymer melt where the acicular calcium carbonate has a particle size in at least one dimension less than 100 angstroms. Chen specifically teaches that the particles have a mean size ranging from 10 nm (*i.e.*, 100 angstroms) to 2.5 microns. (See, e.g., paragraph [0046]). It is respectfully submitted that Chen does not teach or suggest a nano-particle having a particle size in at least one dimension less than 100 angstroms as required by claim 21. Indeed, Applicants submit that Chen teaches away from a nano-particle with a particle size less than 100 angstroms by the recitation of "from 10 nm".

In the Advisory Action dated March 26, 2008, the Office asserts that at the upper end of the claimed range (*i.e.*, "less than 100 angstroms"), one of skill in the art would have expected the calcium carbonate to have the same properties as the lower end of the range disclosed by Chen (*i.e.*, "100 angstroms"). Applicants agree that the upper and of the claimed range and the lower end of the range disclosed in Chen are, indeed, close, but the ranges do not overlap. Also, Applicants submit that the claimed property, namely, a cell orientation of at least about 1.2, is only achieved with a particle size less than 100 angstroms, which is not taught or suggested within Chen.

Additionally, Applicants submit that in order to evaluate the obviousness or non-obviousness of an invention, both the prior art reference(s) and the claimed invention as a

whole must be considered. (*See, e.g.*, MPEP §2141.02 citing *Stratoflex, Inc. v. Aeroquip Corp.*, 713 F.2d 1530, 218 USPQ 871 (Fed Cir. 1983) and *Schenck v. Nortron Corp.*, 713 F.2d 782, 218 USPQ 698 (Fed. Cir. 1983)). As discussed above, Chen teaches that the particles have a size from 10 nm to 2.5 μm . Applicants submit that these ranges are all outside, and some greatly outside, the nano-particle range, *i.e.*, a range from 10-100 nm (*i.e.*, 0.01 μm to 0.1 μm).⁴ Looking at Chen as a whole, it is submitted that the particles utilized in Chen are indeed not nano-particles, and, as a result, one of skill in the art reading Chen would have no motivation to utilize a nano-particle (*i.e.*, acicular calcium carbonate with a particle size in at least one dimension less than 100 angstroms) in a polymer melt to form a foam product as claimed in claim 21.

With respect to Tan, Applicants respectfully submit that Tan teaches the use of calcium carbonate powder, but is silent with respect to any teaching or suggestion of the utilization of acicular calcium carbonate. As taught in Tan, fillers such as calcium carbonate powder may be used to produce an exceptional reinforced foam. (*See, e.g.*, column 4, line 63 to column 5, line 6). There is simply no teaching or suggestion within Tan of the inclusion of acicular calcium carbonate in a polymer melt as is required by claim 21.

In addition, Applicants submit that one of skill in the art reading the disclosures of Miller, Chen, and Tan would have no motivation to include acicular calcium carbonate and at least one nucleating agent into a polymer melt where the acicular calcium carbonate has a particle size in at least one dimension less than 100 angstroms since none of Miller, Chen, or Tan teach or even suggest acicular calcium carbonate having a particle size in at least one dimension less than 100 angstroms. As discussed above, there must be some motivation, either within the reference or in the knowledge of those of skill in the art, to modify the reference or combine the references' teachings. (*See, e.g., Manual of Patent Examining Procedure*, Patent Publishing, LLC, Eighth Ed., Rev. 3, August 2005, §2142). There is simply no motivation within any of Miller, Chen, or Tan to arrive at the polymer melt claimed in claim 21 that includes acicular calcium carbonate and at least one nucleating agent where the acicular calcium carbonate has a particle size in at least one dimension less than 100 angstroms. In fact, Chen teaches away from a particle size less than 100 angstroms and the use of nano-particles in general. Miller and Tan are silent with respect to any teaching or

⁴ *See, e.g.*, Attachment A, <http://en.wikipedia.org/wiki/Nanoparticle>.

suggestion of acicular calcium carbonate. Without some teaching or suggestion, there can be no motivation, and without motivation, there can be no *prima facie* case of obviousness.

Further, Applicants respectfully submit that the combination of the cited references would not result in the presently claimed invention. Neither Chen nor Tan teach or suggest the inclusion of acicular calcium carbonate and at least one nucleating agent into a polymer melt where the acicular calcium carbonate has a particle size in at least one dimension less than 100 angstroms. Miller is silent with respect to any teaching or suggestion of acicular nano-particles. Accordingly, Applicants respectfully submit that the combination of Miller, Chen, and Tan would not include acicular calcium carbonate with a particle size in one dimension less than 100 angstroms as claimed in claim 21. Thus, it is respectfully submitted that independent claim 21, and all claims dependent therefrom, are non-obvious and patentable.

In view of the above, it is respectfully submitted that independent claims 1 and 21 are not taught or suggested by Miller, Chen, or Tan and that claims 1 and 21 are therefore non-obvious and patentable. Because claims 2-8 and 10-15 are dependent upon claim 1, which is not taught or suggested by Miller, Chen, or Tan, in any combination as discussed above, and because claims 2-8 and 10-15 contain the same elements as claim 1, dependent claims 2-8 and 10-15 are also not taught or suggested by Miller, Chen, or Tan.

In light of the above, Applicants submit that claims 1-8, 10-15, and 21 are non-obvious and patentable over Miller in view of Chen or Tan and respectfully request that this rejection be reconsidered and withdrawn.

Rejection of Claims 1-8, 10-15, 21, 23, 25, and 26 under 35 U.S.C. §103(a)

The Office has rejected claims 1-8, 10-15, 21, 23, 25, and 26 as being unpatentable over WO 2001/39954 to Grinshpun, *et al.* ("Grinshpun") in view of WO 2003/055804 to Chen, *et al.* ("Chen") and U.S. Patent No. 7,160,929 to Tan ("Tan"). The Office asserts that Grinshpun teaches a method of manufacturing a rigid foam that includes (1) incorporating fillers and at least one nucleating agent and reinforcing materials such as graphite, conductive carbon black and nanofillers into a polymer, (2) incorporating a blowing agent into the melt under a first temperature and a first pressure, (3) extruding the polymer melt under a second temperature and second pressure to allow the polymer melt to expand and foam, and (4) cooling the foamed product. It is asserted that the foam has a cell size that ranges from 25-

7000 microns. Grinshpun does not specify the shape or particle size of the fillers and reinforcing materials.

In this regard, Chen is cited for assertedly disclosing calcium carbonate whiskers/needles with a particle size as low as 10 nm (100 angstroms). In addition, the Office asserts that Tan teaches the use of nanofibers and nanopowders in the production of nanocomposite foams. The Office concludes that it would have been obvious to one of skill in the art to use a nanofiller, such as acicular calcium carbonate, with a particle size less than 100 angstroms in the method of Grinshpun as taught by Chen and Tan to produce a lightweight material with superior mechanical properties.

Initially, Applicants submit that claims 23, 25, and 26 have been canceled without prejudice, thereby rendering the rejection of these claims moot.

In response to the rejection of claims 1-8 and 10-15, Applicants respectfully submit that Miller, Chen, and Tan do not teach or suggest the incorporation of nano-particles selected from calcium carbonate, intercalated graphites, and expanded graphites that have a particle size in at least one dimension less than 100 angstroms in a polymer melt as required by claim 1. As discussed above, Chen teaches that the disclosed method can produce small mean particle size, superfine calcium carbonate with a size in the range from 10 nm (*i.e.*, 100 angstroms) to 2.5 microns. (*See, e.g.*, paragraph [0048]). Chen does not, however, teach or suggest calcium carbonate having a particle size in at least one dimension that is less than 100 angstroms as is required by claim 1. Indeed, Chen teaches away from a nano-particle having a particle size less than 100 angstroms. Moreover, Chen is silent with respect to any teaching or suggestion of calcium carbonate that is not manufactured to have a specifically formed shape, such as spindle, petal, whisker, needle, flake, ball, and fiber. (*See, e.g.*, paragraph [0001] and the Abstract). Further, Chen is silent with respect to any teaching or suggestion of intercalated graphites and expanded graphites as required by claim 1.

Turning to Tan, Applicants respectfully submit that Tan teaches the use of calcium carbonate powder as a filling agent to produce a reinforced foam with exceptional mechanical properties. (*See, e.g.*, column 4, line 63 to column 5, line 17). Tan is, however, silent with respect to any teaching of the size of the calcium carbonate powder. In fact, the only nano-scale particles disclosed in Tan are reinforcing elements, namely, nano-scale ceramic powder, metal, and carbon fibers. (*See, e.g.*, column 3, lines 64-65 and column 8, lines 29-34). There

is simply no teaching or suggestion within Tan of calcium carbonate having a particle size in at least one dimension less than 100 angstroms as required by claim 1.

In addition, Applicants submit that there is simply no motivation within any of Grinshpun, Chen, or Tan to arrive at the polymer melt claimed in claim 1 that includes a nano-particle selected from calcium carbonate, intercalated graphites, and expanded graphites with a particle size in at least one dimension less than 100 angstroms. Both Grinshpun and Tan are silent with respect to any teaching or suggestion of calcium carbonate having a particle size less than 100 angstroms in one dimension. Chen teaches away from a particle size of less than 100 angstroms. Additionally, none of the cited references teach or suggest the incorporation of intercalated or expanded graphites. There must be some motivation to modify the reference or combine the references' teachings. (*See, e.g., Manual of Patent Examining Procedure*, Patent Publishing, LLC, Eighth Ed., Rev. 3, August 2005, §2142). Without some teaching or suggestion, there can be no motivation, and without motivation, there can be no *prima facie* case of obviousness. Accordingly, Applicants submit that claim 1, and all claims dependent therefrom, are non-obvious and patentable.

Turning to the rejection of claim 21, Applicants submit that none of Grinshpun, Chen, or Tan teach or suggest the inclusion of acicular calcium carbonate and at least one nucleating agent in a polymer melt where the acicular calcium carbonate has a particle size in at least one dimension less than 100 angstroms. Chen specifically teaches that the particles have a mean size ranging from 10 nm (*i.e.*, 100 angstroms) to 2.5 microns. (*See, e.g.*, paragraph [0046]). It is respectfully submitted that Chen does not teach or suggest a nano-particle having a particle size in at least one dimension less than 100 angstroms as required by claim 21. Indeed, Applicants submit that Chen teaches away from a nano-particle with a particle size less than 100 angstroms by the recitation of "from 10 nm".

In the Advisory Action dated March 26, 2008, the Office asserts that at the upper end of the claimed range (*i.e.*, "less than 100 angstroms"), one of skill in the art would have expected the calcium carbonate to have the same properties as the lower end of the range disclosed by Chen (*i.e.*, "100 angstroms"). Applicants agree that the upper and of the claimed range and the lower end of the range disclosed in Chen are, indeed, close, but the ranges do not overlap. Also, Applicants submit that the claimed property, namely, a cell orientation of at least about 1.2, is only achieved with a particle size less than 100 angstroms, which is not taught or suggested within Chen.

Additionally, Applicants submit that in order to evaluate the obviousness or non-obviousness of an invention, both the prior art reference(s) and the claimed invention as a whole must be considered. (*See, e.g.*, MPEP §2141.02 citing *Stratoflex, Inc. v. Aeroquip Corp.*, 713 F.2d 1530, 218 USPQ 871 (Fed Cir. 1983) and *Schenck v. Nortron Corp.*, 713 F.2d 782, 218 USPQ 698 (Fed. Cir. 1983)). As discussed above, Chen teaches that the particles have a size from 10 nm to 2.5 μm . Applicants submit that these ranges are all outside, and some greatly outside, the nano-particle range, *i.e.*, a range from 10-100 nm (*i.e.*, 0.01 μm to 0.1 μm).⁵ Looking at Chen as a whole, it is submitted that the particles utilized in Chen are indeed not nano-particles, and, as a result, one of skill in the art reading Chen would have no motivation to utilize a nano-particle (*i.e.*, acicular calcium carbonate with a particle size in at least one dimension less than 100 angstroms) in a polymer melt to form a foam product as claimed in claim 21.

With respect to Tan, Applicants respectfully submit that Tan teaches the use of calcium carbonate powder, but is silent with respect to any teaching or suggestion of the utilization of acicular calcium carbonate. As taught in Tan, fillers such as calcium carbonate powder may be used to produce an exceptional reinforced foam. (*See, e.g.*, column 4, line 63 to column 5, line 6). There is simply no teaching or suggestion within Tan of the inclusion of acicular calcium carbonate in a polymer melt as is required by claim 21.

In addition, Applicants submit that one of skill in the art reading the disclosures of Grinshpun, Chen, and Tan would have no motivation to include acicular calcium carbonate and at least one nucleating agent in a polymer melt where the acicular calcium carbonate has a particle size in at least one dimension less than 100 angstroms since none of Grinshpun, Chen, or Tan teach or even suggest acicular calcium carbonate with a particle size in at least one dimension less than 100 angstroms. As discussed above, there must be some motivation, either within the reference or in the knowledge of those of skill in the art, to modify the reference or combine the references' teachings. (*See, e.g., Manual of Patent Examining Procedure*, Patent Publishing, LLC, Eighth Ed., Rev. 3, August 2005, §2142). There is simply no motivation within any of Grinshpun, Chen, or Tan to arrive at the polymer melt claimed in claim 21 that includes acicular calcium carbonate and at least one nucleating agent in a polymer melt where the acicular calcium carbonate has a particle size in at least one

⁵ *See, e.g.*, Attachment A, <http://en.wikipedia.org/wiki/Nanoparticle>.

dimension less than 100 angstroms. In fact, Chen teaches away from a particle size less than 100 angstroms and from the use of nano-particles in general. Grinshpun and Tan are silent with respect to any teaching or suggestion of acicular calcium carbonate. Without some teaching or suggestion, there can be no motivation, and without motivation, there can be no *prima facie* case of obviousness.

Additionally, Applicants respectfully submit that the combination of the cited references would not result in the presently claimed invention. Neither Chen nor Tan teach or suggest the inclusion of acicular calcium carbonate and at least one nucleating agent into a polymer melt where the acicular calcium carbonate has a particle size in at least one dimension less than 100 angstroms. Grinshpun is silent with respect to any teaching or suggestion of acicular nano-particles. Accordingly, Applicants respectfully submit that the combination of Grinshpun, Chen, and Tan would not include acicular calcium carbonate with a particle size in one dimension less than 100 angstroms as claimed in claim 21. Thus, it is respectfully submitted that independent claim 21, and all claims dependent therefrom, are non-obvious and patentable.

In view of the above, it is respectfully submitted that independent claims 1 and 21 are not taught or suggested by Grinshpun, Chen, or Tan and that claims 1 and 21 are therefore non-obvious and patentable. Because claims 2-8 and 10-15 are dependent upon claim 1, which is not taught or suggested by Grinshpun, Chen, or Tan, in any combination as discussed above, and because claims 2-8 and 10-15 contain the same elements as claim 1, dependent claims 2-8 and 10-15 are also not taught or suggested by Grinshpun, Chen, or Tan.

In light of the above, Applicants submit that claims 1-8, 10-15, and 21 are non-obvious and patentable over Grinshpun in view of Chen or Tan and respectfully request that this rejection be reconsidered and withdrawn.

Rejection of Claims 25 and 26 under 35 U.S.C. §103(a)

The Office has rejected claims 25 and 26 as being unpatentable over WO 2001/39954 to Grinshpun, *et al.* ("Grinshpun") in view of U.S. Patent No. 6,759,446 to Lee, *et al.* ("Lee"). The Office asserts that Grinshpun teaches a method of manufacturing a rigid foam that includes (1) incorporating fillers and at least one nucleating agent and reinforcing materials such as graphite, conductive carbon black and nanofillers into a polymer, (2) incorporating a blowing agent into the melt under a first temperature and a first pressure, (3)

extruding the polymer melt under a second temperature and second pressure to allow the polymer melt to expand and foam, and (4) cooling the foamed product. It is asserted that the foam has a cell size that ranges from 25-7000 microns. Further, it is asserted that Grinshpun discloses the use of additives such as flame retardants, pigments, and extrusion aids. The Office asserts that Grinshpun does not explicitly teach that the nano-particle fillers are nanoclays or intercalated or expanded graphite having the claimed particle size.

In this regard, Lee is cited for teaching an analogous method of producing a rigid foam where nanoclays having a thickness of less than 1 nm (10 angstroms) are used. Lee assertedly discloses the use of a modified nano-Montmorillonite intercalated with polystyrene. The Office concludes that it would have been obvious to one of skill in the art to employ the nanoclays of Lee in the method of Grinshpun to improve the physical properties of the foam.

Applicants respectfully submit that claims 25 and 26 have been canceled without prejudice, thereby rendering this rejection moot. Accordingly, Applicants respectfully request that the Office remove this rejection.

Rejection of Claims 25 and 26 under 35 U.S.C. §103(a)

The Office has rejected claims 25 and 26 as being unpatentable over WO 2001/40362 to Miller, *et al.* ("Miller") in view of U.S. Patent No. 6,518,324 to Kresta, *et al.* ("Kresta"). In particular, the Office asserts that Miller teaches the claimed process of producing an extruded foam product where a blowing agent is incorporated into the polymer melt at a first pressure and temperature, extruding the polymer melt under a second pressure and temperature to form a foam, and intrinsically cooling the foam to form a product with a cell size within the claimed range. It is asserted that the preferred polymer melt includes an alkenyl aromatic polymer material. The Office asserts that Miller discloses the addition of additives such as plasticizers and flame retardants to the resin/foamable mixture. The Office admits that Miller does not teach acicular nano-particles as claimed.

In this regard, Kresta is cited for assertedly teaching the use of nanoclays having a thickness from 3-1000 angstroms in polymer foams, such as polystyrene foams. The Office asserts that Kresta teaches that the nanoclays are extruded with a major portion of the polystyrene. The Office concludes that it would have been obvious to use the nanoclays of Kresta in the method of Miller to produce a foam with improved thermal insulation values.

Applicants respectfully submit that claims 25 and 26 have been canceled without prejudice, thereby rendering this rejection moot. Accordingly, Applicants respectfully request that the Office remove this rejection.

Conclusion


In light of the above, Applicants believe that this application is now in condition for allowance and therefore request favorable consideration.

If any points remain in issue which the Office feels may be best resolved through a personal or telephone interview, the Office is kindly requested to contact the undersigned at the telephone number listed below.

If necessary, the Commissioner is hereby authorized to charge payment or credit any overpayment to Deposit Account No. 50-0568 for any additional fees required under 37 C.F.R. § 1.16 or under 37 C.F.R. § 1.17; particularly, extension of time fees.

Respectfully submitted,

Date: 4/26/08



Jason S. Fokens
Registration No. 56,188

Owens Corning
Patent Department, Bldg. 21-0
2790 Columbus Road
Granville, Ohio 43023
(740) 321-7315

Attachment A

Nanoparticle

From Wikipedia, the free encyclopedia

A **nanoparticle** (which historically has included **nanopowder**, **nanocluster**, and **nanocrystal**) is a small particle with at least one dimension less than 100 nm. This definition can be fleshed out further in order to remove ambiguity from future nano nomenclature. A **nanoparticle** is an amorphous or semicrystalline zero dimensional (0D) nano structure with at least one dimension between 10 and 100nm and a relatively large (> 15%) size dispersion.^[1] A **nanocluster** is an amorphous/semicrystalline nanostructure with at least one dimension being between 1-10nm and a narrow size distribution.^[2] This distinction is an extension of the term "cluster" which is used in inorganic/organometallic chemistry to indicate small molecular cages of fixed sizes. A **nanopowder** is an agglomeration of noncrystalline nanostructural subunits with at least one dimension less than 100nm.^[3] A **nanocrystal** is any nonamaterial with at least one dimension $\leq 100\text{nm}$ and that is singlecrystalline.^[4] Any particle which exhibits regions of crystallinity should be termed nanoparticle or nanocluster based on dimensions. Nanoparticle research is currently an area of intense scientific research, due to a wide variety of potential applications in biomedical, optical, and electronic fields. The National Nanotechnology Initiative of the United States government has driven huge amounts of state funding exclusively for nanoparticle research.

Contents

- 1 History
- 2 Properties
- 3 Classification
- 4 Characterization
- 5 Fabrication of nanoparticles
- 6 Nanoparticle Morphology
- 7 Safety Issues
- 8 See also
- 9 References
- 10 External links

Part of a series of articles on Nanomaterials

Fullerenes
Carbon nanotubes
Fullerene chemistry
Applications
In popular culture
Timeline
Carbon allotropes

Nanoparticles
Quantum dots
Nanostructures
Colloidal gold
Iron nanoparticles

See also
Nanotechnology

History

Although generally nanoparticles are considered an invention of modern science, they actually have a very long history. Specifically, nanoparticles were used by artisans as far back as in the 9th century Mesopotamia for generating a glittering effect on the surface of pottery.

Even these days pottery from the Middle Ages and Renaissance often retain a distinct gold or copper colored metallic glitter. This so called lustre is caused by a metallic film that was applied to the transparent surface of a glazing. The lustro can still be visible if the film has resisted atmospheric oxidation and other weathering.

The lustre originates within the film itself, which contains silver and copper nanoparticles, dispersed homogeneously in the glassy matrix of the ceramic glaze. These nanoparticles were created by the artisans by adding copper and silver salts and oxides together with vinegar, ochre, and clay, on the surface of previously-glazed pottery. The object was then placed to a kiln and heated to about 600°C in a reducing atmosphere.

In the heat the glaze would soften, causing the copper and silver ions to migrate into the outer layers of the glaze. There the reducing atmosphere reduced the ions back to metals, which then came together forming the nanoparticles that give the colour and optical effects.

Usage of the lustre technique shows that craftsmen had a technological and empirical knowledge of materials science that was far ahead of their time. The technique originates in the Islamic world. As Muslims were not allowed to use gold in artistic representations, they had to find a way to create a similar effect without using real gold. The solution they found was using lustre.

Much of the modern day studies of these objects have been conducted at the ESRF laboratory. Several techniques were used to characterise the chemical and physical properties of these lustre, such as Rutherford Backscattering Spectrometry (RBS), optical absorption in the visible-ultraviolet region, electron microscopy (TEM and SEM), X-ray diffraction and X-ray absorption spectroscopy.^[5]

Properties

Nanoparticles are of great scientific interest as they are effectively a bridge between bulk materials and atomic or molecular structures. A bulk material should have constant physical properties regardless of its size, but at the nano-scale this is often not the case. Size-dependent properties are observed such as quantum confinement in semiconductor particles, surface plasmon resonance in some metal particles and superparamagnetism in magnetic materials.

The properties of materials change as their size approaches the nanoscale and as the percentage of atoms at the surface of a material becomes significant. For bulk materials longer than one micrometre the percentage of atoms at the surface is minuscule relative to the total number of atoms of the material. The interesting and sometimes unexpected properties of nanoparticles are partly due to the aspects of the surface of the material dominating the properties in lieu of the bulk properties.

Nanoparticles exhibit a number of special properties relative to bulk material. For example, the bending of bulk copper (wire, ribbon, etc.) occurs with movement of copper atoms/clusters at about the 50 nm scale. Copper nanoparticles smaller than 50 nm are considered super hard materials that do not exhibit the same malleability and ductility as bulk copper. The change in properties is not always desirable. Ferroelectric materials smaller than 10 nm can switch their magnetisation direction using room temperature thermal energy, thus making them useless for memory storage. Suspensions of nanoparticles are possible because the interaction of the particle surface with the solvent is strong enough to overcome differences in density, which usually result in a material either sinking or floating in a liquid. Nanoparticles often have unexpected visible properties because they are small enough to confine their electrons and produce quantum effects. For example gold nanoparticles appear deep red to black in solution.

Nanoparticles have a very high surface area to volume ratio. This provides a tremendous driving force for diffusion, especially at elevated temperatures. Sintering can take place at lower temperatures, over shorter time scales than for larger particles. This theoretically does not affect the density of the final product, though flow difficulties and the tendency of nanoparticles to agglomerate complicates matters. The large surface area to volume ratio also reduces the incipient melting temperature of nanoparticles^[6].

Classification

At the small end of the size range, nanoparticles are often referred to as clusters. Nanospheres, nanorods, and nanocups are just a few of the shapes that have been grown.

Metal, dielectric, and semiconductor nanoparticles have been formed, as well as hybrid structures (e.g., core-shell nanoparticles). Nanoparticles made of semiconducting material may also be labeled quantum dots if they are small enough (typically sub 10 nm) that quantization of electronic energy levels occurs. Such nanoscale particles are used in biomedical applications as drug carriers or imaging agents.

Semi-solid and soft nanoparticles have been manufactured. A prototype nanoparticle of semi-solid nature is the liposome. Various types of liposome nanoparticles are currently used clinically as delivery systems for anticancer drugs and vaccines.

Characterization

Nanoparticle characterization is necessary to establish understanding and control of nanoparticle synthesis and applications. Characterization is done by using a variety of different techniques, mainly drawn from materials science. Common techniques are electron microscopy [TEM, SEM], atomic force microscopy [AFM], dynamic light scattering [DLS], x-ray photoelectron spectroscopy [XPS], powder x-ray diffractometry [XRD], and Fourier transform infrared spectroscopy [FTIR].

Whilst the theory has been known for over a century (see Robert Brown), the technology for Nanoparticle tracking analysis (NTA) allows direct tracking of the Brownian motion and this method therefore allows the sizing of individual nanoparticles in solution.

Fabrication of nanoparticles

There are several methods for creating nanoparticles; attrition and pyrolysis are common methods. In attrition, macro or micro scale particles are ground in a ball mill, a planetary ball mill, or other size reducing mechanism. The resulting particles are air classified to recover nanoparticles.

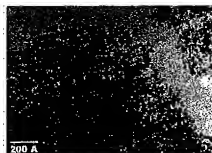
In pyrolysis, an organic precursor (liquid or gas) is forced through an orifice at high pressure and burned. The resulting ash is air classified to recover oxide nanoparticle.

A thermal plasma can also deliver the energy necessary to cause evaporation of small micrometre size particles. The thermal plasma temperatures are in the order of 10000 K, so that solid powder easily evaporates. Nanoparticles are formed upon cooling while exiting the plasma region. The main types of the thermal plasmas torched used to produce nanoparticles are dc plasma jet, dc arc plasma and radio frequency (RF) induction plasmas. In the arc plasma reactors, the energy necessary for evaporation and reaction is provided by an electric arc which forms between the anode and the cathode. For example, silica sand can be vaporized with an arc plasma at atmospheric pressure. The resulting mixture of plasma gas and silica vapour can be rapidly cooled by quenching with oxygen, thus ensuring the quality of the fumed silica produced. In RF induction plasma torches, energy coupling to the plasma is accomplished through the electromagnetic field generated by the induction coil. The plasma gas does not come in contact with electrodes, thus eliminating possible sources of contamination and allowing the operation of such plasma torches with a wide range of gases including inert, reducing, oxidizing and other corrosive atmospheres. The working frequency is typically between 200 kHz and 40 MHz. Laboratory units run at power levels in the order of 30-50 kW while the large scale industrial units have been tested at power levels up to 1 MW. As the residence time of the injected feed droplets in the plasma is very short it is important that the droplet sizes are small enough in order to obtain complete evaporation. The RF plasma method has been used to synthesize different nanoparticle materials, for example synthesis of various ceramic nanoparticles such as oxides, carbours/carbides and nitrides of Ti and Si.

Inert-gas aggregation is frequently used to make nanoparticles from metals with low melting points. The metal is vaporized in a vacuum chamber



Silicon nanopowder



Nanodiamonds, TEM image

and then supercooled with an inert gas stream. The supercooled metal vapor condenses in to nanometer-sized particles, which can be entrained in the inert gas stream and deposited on a substrate or studied *in situ*.

Nanoparticle Morphology



Nanostars of Vanadium(IV) oxide

Scientists have taken to naming their particles after the real world shapes that they might represent. Nanospheres^[7], nanorods^[8], nanoboxes^[9] and more have appeared in the literature. These morphologies sometimes arise spontaneously as an effect of a templating or directing agent present in the synthesis such as micellar emulsions or anodized alumina pores, or from the innate crystallographic growth patterns of the materials themselves.^[10] Some of these morphologies may serve a purpose, such as long carbon nanotubes being used to bridge an electrical junction, or just a scientific curiosity like the stars shown at left.

Safety Issues

See also: *Nanotoxicology* and *Fine particles*

Nanoparticles present possible dangers, both medically and environmentally.^[11] Most of these are due to the high surface to volume ratio, which can make the particles very reactive or catalytic.^[12] They are also able to pass through cell membranes in organisms, and their interaction with biological systems are relatively unknown.^[13] However, free nanoparticles in the environment quickly tend to agglomerate and thus leave the nano-regime, and nature itself presents many nanoparticles to which organisms on earth may have evolved immunity (such as salt particulates from ocean aerosols, terpenes from plants, or dust from volcanic eruptions). A fuller analysis is provided in the article on nanotechnology.

According to the *San Francisco Chronicle*, "Animal studies have shown that some nanoparticles can penetrate cells and tissues, move through the body and brain and cause biochemical damage. But whether cosmetics and sunscreens containing nanomaterials pose health risks remains largely unknown, pending completion of long-range studies recently begun by the FDA and other agencies."^[14] Diesel nanoparticles have been found to damage the cardiovascular system in a mouse model.^[15]

See also

- Quantum dot
- Nanocrystalline silicon
- Photonic crystal
- Nanotechnology
- Nanobiotechnology
- Liposome
- Nanomaterials
- Nanoparticle Tracking Analysis

References

- ↑ Fählan, B. D. *Materials Chemistry*; Springer: Mount Pleasant, MI, 2007; Vol. 1, pp 282-283.
- ↑ Fählan, B. D. *Materials Chemistry*; Springer: Mount Pleasant, MI, 2007; Vol. 1, pp 282-283.
- ↑ Fählan, B. D. *Materials Chemistry*; Springer: Mount Pleasant, MI, 2007; Vol. 1, pp 282-283.
- ↑ Fählan, B. D. *Materials Chemistry*; Springer: Mount Pleasant, MI, 2007; Vol. 1, pp 282-283.
- ↑ Montserrat Capellas Espuny. "Renaissance Artists Decorated Pottery With Nanoparticles", ESRF Newsletter No 38, December 2003. Retrieved on 2007-07-28.
- ↑ Buffat, Ph. & Burel, J.-P. (1976). "Size effect on the melting temperature of gold particles", *Physical Review A* 13 (5): 2287 - 2298, doi:10.1103/PhysRevA.13.2287, <<http://link.aps.org/absraa/PRA/v13/p2287>>
- ↑ Agam and Guo. Electron beam modification of polymer nanospheres. *Journal of Nanoscience and Nanotechnology* 7 (2007) 361-5. JOURNAL OF NANOSCIENCE AND NANOTECHNOLOGY 7 (10): 3615-3619 OCT 2007 doi:10.1166/jnn.2007.814
- ↑ Chey JH, Jung ES, Won JH, Chung JH, Jang DJ, and Kim YW. Hydrothermal route to ZnO nanocoral reefs and nanofibers. *Appl. Phys. Lett.* 84 (2004) 287.
- ↑ Yuzang Sun and Younan Xia *Science* 298 (2002) 2176. doi:10.1126/science.1077229
- ↑ Catherine Murphy, *Science* 298 (2002) 2139. doi:10.1126/science.1080007 10.1126/science.1080007
- ↑ Anisa Myusivalli, Abdallah S Daar and Peter A Singer 2003 Nanotechnology 14 R9-R13 doi:10.1088/0957-4484/14/3/201
- ↑ Ying, Jackie. Nanostructured Materials. New York: Academic Press, 2001.
- ↑ Nanotechnologies: 6. What are potential harmful effects of nanoparticles?
- ↑ Keay Davidson. "FDA urged to limit nanoparticle use in cosmetics and sunscreens", San Francisco Chronicle. Retrieved on 2007-04-20.
- ↑ <http://www.bloomberg.com/apps/news?pid=washingtonstory&sid=aBtYtLfYf0o> study Pollution Particles Lead to Higher Heart Attack Risk (Update1)

External links

- A wide variety of nanoparticles and their dispersions are commercially available
- International Liposome Society
- Assessing health risks of nanoparticles summary by

GreenFacts of the European Commission SCENIHR assessment

- [1]
- [http://books.google.com/books?id=pbtbJwkj5YC&pg=PA5&dq=catalyst+hartog+1972&source=web&ots=JTTD2SA5Dh&sig=3phv63YeG9raeAZdvlm_4JH07Y#PPR7,M1]

Retrieved from "http://en.wikipedia.org/wiki/Nanoparticle"

Categories: Nanotechnology | Nanomaterials

Hidden categories: All articles with unsourced statements | Articles with unsourced statements since August 2007 | Articles lacking sources from November 2006 | All articles lacking sources

- This page was last modified on 23 February 2008, at 17:21.
- All text is available under the terms of the GNU Free Documentation License. (See **Copyrights** for details.)
Wikipedia® is a registered trademark of the Wikimedia Foundation, Inc., a U.S. registered 501(c)(3) tax-deductible nonprofit charity.